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TICKS OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL

Harry D. Pratt, et al

Communicable Disease Center
Atlanta, Georgia

1962

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TICKS

OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL

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TICKS OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL

TRAINING GUIDE - INSECT CONTROL SERIES

Harry D. Pratt and Kent S. Littig

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Atlanta, Georgia

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INTRODUCTION

Smith and Kilbourne performed historic experiments from 1889 to 1893 bringing to light the importance of arthropods as vectors of disease. Their discovery that the cattle tick was the vector of the dread Texas cattle fever spurred on the search for vectors of spotted fever, malaria, and other diseases. Soon afterward (1902-1906) Ricketts incriminated the wood tick, Dermacentor andersoni, in the transmission of Rocky Mountain spotted fever. Further work implicated the American dog tick, Dermacentor variabilis, and the lone star tick, Amblyomma americanum, as vectors of this malady east of the wood tick range. Tularemia, Colorado tick fever, relapsing fever, and Q fever were later added to the list of tick-borne diseases. Tick paralysis has received increased attention by both physicians and veterinarians. Recent research indicated that ticks play a role in the epidemiology of some of the arthropod-borne encephalitides.

At present, ticks are known to transmit five groups of deadly diseases: (1) rickettsial, such as spotted fever, (2) bacterial, such as tularemia, (3) spirochetal, such as relapsing fevers, (4) viral, such as Colorado tick fever, and (5) protozoal diseases, such as Texas cattle fever. They also produce a toxic paralysis. In some areas ticks are vicious, bloodsucking pests that cause great discomfort.

Although ticks belong to the Class Arachnida, and are not true insects, they are important vectors of some of the most significant arthropod-borne diseases and have been studied intensively by entomologists and public health workers. For this reason this Training Guide on ticks has been included in the Insect Control Series.

TICKS AND HUMAN WELFARE

RICKETTSIAL DISEASES

Rocky Mountain Spotted Fever

Spotted fever is a febrile disease caused by Rickettsia rickettsii. The wood tick, Dermacentor andersoni, and the rabbit tick, Haemaphysalis leporispalustris, spread the disease from animal to animal in the West. According to Larson (1955) Dermacentor andersoni is the most important western vector to man, both male and female ticks being infective. Dermacentor occidentalis is a suspected vector on the west coast. The American dog tick, Dermacentor variabilis, is the most important vector in the East. The lone star tick, Amblyomma americanum, is probably a vector in parts of eastern United States and in Texas, Oklahoma, and Arkansas.

The Dermacentor ticks are well suited as vectors of spotted fever because the larvae and nymphs feed on rodents and the adults attack man and

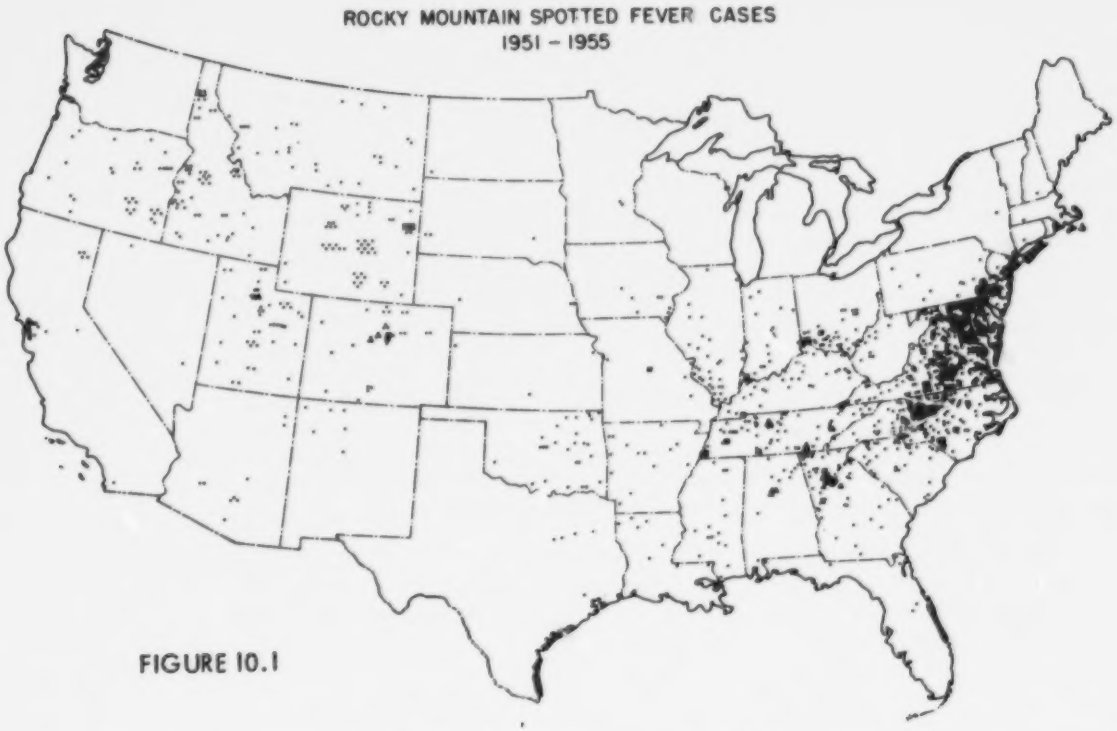


FIGURE 10.1

other large mammals. Fortunately, transmission of the disease does not occur unless the tick remains attached to its host for two or more hours.

Spotted fever has been reported from 46 of the 50 states. This disease is not contracted in Hawaii or Alaska, and is seldom reported inland in New England or New York, or in the West Central states. The greatest number of cases in the 5-year period 1951-1955 were reported from the South Atlantic states, particularly Virginia, Maryland, and North Carolina (Figure 10.1). Great differences in the virulence of the disease have been reported, with the western strain considered more virulent than the eastern. However, Cox (in Rivers et al, 1959, p. 843) has reported that on the average, the fatality rate for spotted fever is about as high in the East as it is in the West.

The number of cases of spotted fever officially reported to the Public Health Service has decreased over 50 percent in the past fifteen years, from almost 600 cases in 1946 and 1947 to less than 300 in each of the six years 1954 to 1959, and 204 in 1960. Some of this reduction has been explained by McCroan et al. (1955) as follows: "The rickettsial infections are so well masked by antibiotics that many cases are aborted and diagnosis with complete laboratory confirmation is a rarity. Development of complement-fixing antibodies is delayed sometimes for 6 or more months. Confirmation

of diagnosis in recent years has been achieved largely as the result of epidemiologic follow-up of cases by public health agencies."

Vaccination affords a high degree of protection to people who are frequently exposed to tick bites, e.g., fishermen, cowboys, sheep herders, and lumbermen. Vaccine made from chick embryos heavily infected with the rickettsial organisms is available. Initially, three injections are given at 5 to 7-day intervals, and each year thereafter a booster shot is given. New antibiotic drugs such as aureomycin, chloromycetin, and terramycin, have proven of great value in the treatment of clinical cases.

Q Fever

Q fever (Query fever) is a rickettsial disease which has also been known as nine-mile fever. The causative organism, Coxiella burnetii, has caused outbreaks among stockyard workers in Australia and the United States. The disease has been reported from all continents and in ever widening localities (Philip, 1953). The wood tick, lone star tick, spinose ear tick and many other species have been found infected. Tick tissues and feces become massively infected with this rickettsial agent. It is suspected that humans may inhale the disease organisms with dust and droplets contaminated with material from infected animals. Vaccination of persons exposed to infection is of proved protective value, according to Hunter, et al. (1960).

Bullis Fever

This disease was first recognized in 1941 at Camp Bullis, Texas. Isolations of rickettsiae from cases and from the lone star tick have been reported. This disease is not definitely known to be tick-borne, but the lone star tick appears to be the vector.

BACTERIAL DISEASES

Tularemia

Tularemia, or rabbit fever, is a plague-like disease of rabbits and rodents that is transmissible to man. This disease may cause heavy losses in sheep. The disease bacillus, Pasteurella tularensis, infects a wide variety of hosts, being especially prevalent in rabbits and hares. Tularemia is transmitted among these hosts by ticks of the genera Dermacentor and Haemaphysalis, which may transmit the disease organisms to their own offspring through the egg and from one stage to another. Ixodes ticks also serve as vectors in nature, but passage of the bacillus through the egg is not known (Philip and Burgdorfer, 1961). Human beings acquire the disease by contact with infected rabbits and other animals, with the feces of infected ticks, and by tick bite. Other blood-sucking arthropods such as the deer fly (Chrysops discalis) may be of importance in the spread of this disease.

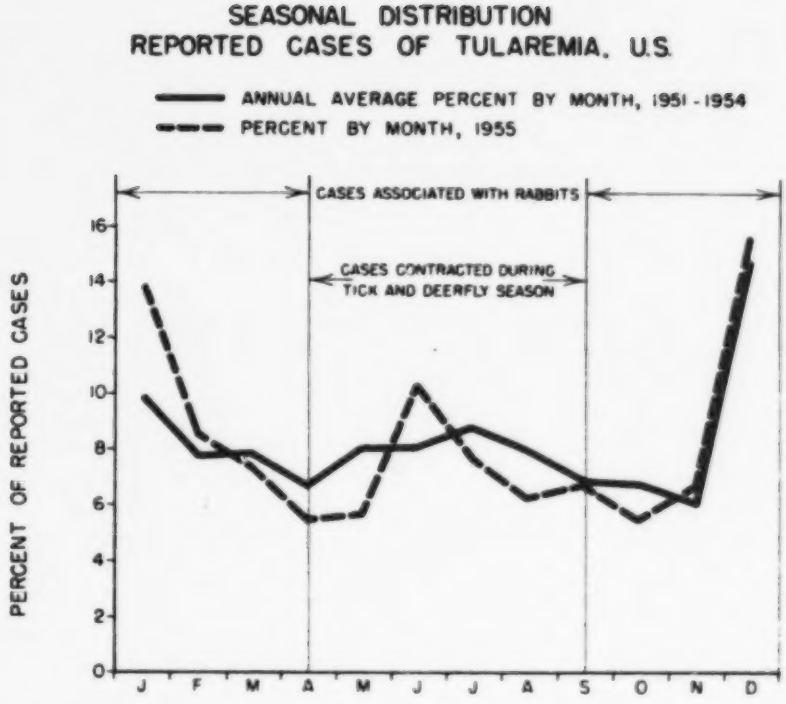


FIGURE 10.2

The monthly distribution of reported cases of tularemia in the United States for 1951-1955 is shown in Figure 10.2. Two peaks are evident -- the spring-summer peak usually associated with infections from the bite of ticks and deer flies, and the fall-winter peak attributed to physical contact with diseased animals, particularly rabbits and hares.

At present no vaccine is available for protection against tularemia, but the drug streptomycin is most effective in treating clinical cases of the disease.

SPIROCHETAL DISEASES

The Relapsing Fevers

Two distinct entities known as relapsing fever, one tick-borne, the other louse-borne, show only minor clinical variations and are distinguishable by differences in mode of transmission and geographic distribution. These diseases occur on every continent with the possible exception of Australia. They are caused by the spirochetes in the genus Borrelia, the louse-borne type most frequently due to Borrelia recurrentis and the tick-borne type to a number of species of Borrelia. Louse-borne relapsing fever is not known to occur in the United States at the present time.

In the United States relapsing fever spirochetes are transmitted by soft ticks in the genus Ornithodoros in limited areas in 13 western states. Investigations by Davis (1942) indicate that each species of Ornithodoros that is a relapsing fever vector carries a spirochete that is tick host-specific; thus O. hermsi transmits Borrelia hermsi and O. parkeri transmits Borrelia parkeri without cross-infections between the species. In the United States there are four species which are proved vectors of relapsing fever spirochetes: O. hermsi in California, Nevada, Idaho, Oregon, Washington, and Colorado; O. turicata and O. talaje in the United States from Florida to California and northward to Kansas, Colorado, and Utah: and O. parkeri in northwestern United States. Ticks remain infective for life and pass the spirochetes to their offspring. Both ticks and their rodent hosts may serve as reservoirs for the disease. Infections of humans are believed to take place by contamination of the wound or skin by tick secretions in some species. O. turicata, O. parkeri, and O. hermsi definitely infect by the bite (Hunter, Frye, Swartzwelder, 1960).

VIRAL DISEASES

Colorado Tick Fever

This is a virus disease of short duration characterized by intermittent fever, leukopenia (reduction of white corpuscles in the blood), and absence of the rash usually associated with rickettsial diseases. Human cases are known to occur in the Rocky Mountain area from Washington, Idaho, Montana, and Wyoming south to Utah and Colorado, which is the range of the vector, the wood tick, D. andersoni. Preliminary data indicate that the number of reported cases in Colorado, Idaho, Montana, Utah, and Wyoming has increased markedly in recent years, from 123 cases in 1956 to 290 in 1960. Although isolations of the virus from the American dog tick, D. variabilis, have been claimed, no human cases attributable to this tick have been reported. Prevention of Colorado tick fever depends primarily on avoidance of tick-infected areas, early removal of ticks, and use of repellents.

PROTOZOAL DISEASES

Cattle Tick Fever

Cattle tick fever, or Texas cattle fever, is a deadly disease of cattle caused by tiny protozoans (Babesia bigemina) which destroy the red blood cells. This disease is transmitted by the cattle tick (Boophilus annulatus) or the tropical cattle tick (Boophilus microplus). At one time the disease occurred in 16 states from California eastward and from Texas northward to Kentucky and Virginia, causing losses to stockman as high as $40,000,000 a year. It has virtually been wiped out in the United States by such drastic measures as quarantine and compulsory cattle dipping, but still causes enormous losses in the tropics throughout the world.

Anaplasmosis

Anaplasmosis is another protozoan disease of cattle, caused by Anaplasma marginale, which is transmitted by Boophilus ticks throughout the

tropics and subtropics. In the United States this disease is also transmitted by Dermacentor and Amblyomma ticks, and by biting flies. It is a very important disease in the lower Mississippi Valley and in the western United States. The parasites may be transferred mechanically on infected mouthparts from an infected animal to healthy ones or ticks may serve as biological carriers and reservoirs with transovarial and transstadial transmission of the protozoa (Hagan and Bruner, 1961).

TICK BITE AND TICK PARALYSIS

Ticks afflict man and other mammals by their irritating bites and by tick paralysis associated with their toxic secretions. The insertion of the mouthparts into the skin produces an inflammatory reaction. If the tick is removed too forcibly, the mouthparts may be torn off and left in the wound. Such an injury often becomes infected, producing an inflamed sore or ulcer and, occasionally, blood poisoning. Larvae, or "seed" ticks, can become attached in such abundance as to cause severe itching and redness of large areas of the body similar to that caused by chiggers. Hard ticks, which remain attached for a long time, are most apt to create this problem. Soft ticks tend to remain attached for short periods of time, being comparable to bed bugs in this respect. Deer and moose frequently die from loss of blood associated with heavy infestations of the winter tick, D. albipictus, while domestic rabbits may be practically exsanguinated with as few as 60 to 75 female D. andersoni feeding over a period of about 12 days (Jellison and Kohls, 1938).

Tick paralysis, usually produced by the engorging female tick, is probably caused by a neurotoxic substance in the tick saliva, possibly a foreign protein such as partially digested blood. The symptoms develop about 6 days after the tick becomes attached and while engorgement is well under way. There is a rapid upward progression of flaccid paralysis starting with the feet and legs and extending to the face, tongue, and pharynx, sometimes ending with respiratory failure and death. Tick paralysis is most frequently observed in children under 7 years of age with a rather high fatality rate, 12 deaths in 94 people (12.7% mortality rate) in the United States and 27 deaths in 238 cases in the Pacific Northwest (11% mortality rate) according to Jellison and Gregson (1950) and Rose (1954). In North America the wood tick and the American dog tick are the two species that most commonly cause tick paralysis. This disease is most frequently observed in the Northwest and in the southeastern states (Herms and James, 1961). The usual site of tick attachment is the scalp, particularly the back of the head. Persons camping or hiking should prevent tick attachment by thorough inspection of the body and garments and the use of tick repellents and protective clothing. Small girls are the most subject to tick paralysis, as their long hair can conceal the ticks. Grown persons are rarely paralyzed. Recovery of patients is rapid following simple removal of the engorging tick and application of suitable antiseptic. Tick paralysis also occurs in dogs and cattle.

TABLE 10.1 - TICK-BORNE DISEASES IN THE UNITED STATES

Name of Disease	Disease Organism	Type of Organism	Tick Vector
Rocky Mountain spotted fever	*Rickettsia rickettsii*	rickettsia	*Dermacentor variabilis* *D. andersoni* *D. occidentalis* *** *Amblyomma americanum* *Haemaphysalis leporispalustris* *
Tularemia	*Pasteurella tularensis*	bacterium	*D. variabilis* *D. andersoni* *H. leporispalustris* * *Amblyomma americanum*
Relapsing fevers	*Borrelia* spp.	spirochete	*Ornithodoros hermsi*, *O. talaje* *O. parkeri*, *O. turicata*
Colorado tick fever	virus	virus	*D. andersoni*
Q fever	*Coxiella burnetii*	rickettsia	*D. andersoni* *A. americanum* *Otobius megnini* ***
Tick paralysis	-------no organism, toxic secretion------		*D. variabilis* *D. andersoni*
Anaplasmosis **	*Anaplasma* spp.	protozoan	Many tick species
Cattle tick fever **	*Babesia bigemina*	protozoan	*Boophilus annulatus*, *B. microplus*
Bullis fever	unknown	rickettsia (?)	*Amblyomma americanum* (?)

* Transmits disease among rabbits
** Disease of cattle
*** Found infected in nature but transmission to man has not been reported

THE MORPHOLOGY OF TICKS

CHARACTERISTICS AND SYSTEMATIC POSITION

Ticks are members of the Class Arachnida which includes other important arthropods such as mites, spiders, and scorpions. Ticks have three characters which distinguish them from the insects: the head, thorax, and abdomen are all fused into one body region; they have no antennae; and in the nymph and adult stages they have four pairs of legs. In true insects, on the other hand, the body is divided into three regions known as head, thorax, and abdomen; they possess a single pair of antennae; and when fully grown they have three pairs of legs.

The order Acarina (ticks and mites) usually differs from other arachnids in that the body is not segmented; the cephalothorax and abdomen are fused to form one body region.

Ticks belong to the suborder Ixodides of the order Acarina. They can be distinguished from other Acarina by two characters: the tarsus of the first leg has a conspicuous sensory pore known as Haller's organ; and most species have a prominent, toothed hypostome not found in mites or chiggers.

There are two main groups: the soft ticks and the hard ticks. The soft ticks (family Argasidae) do not possess a scutum, or hard dorsal shield (Figure 10.4). The hard ticks (family Ixodidae) have a dorsal shield or scutum (Figure 10.4) immediately behind the capitulum. The dorsal shield is small in the female, but covers most of the dorsal surface of the male (Figure 10.7). In the United States hard ticks are much more abundant than soft ticks, cause greater annoyance, and are far more important in the transmission of diseases to man and his animals.

EXTERNAL MORPHOLOGY

The Mouthparts

Ticks do not possess a true head, but have a capitulum (Figure 10.3) consisting of a basal portion, the basis capituli, to which the hypostome, chelicerae, and palps are attached. The hypostome is a piercing organ typically bearing many rows of recurved barbs which anchor the tick to the skin of its host. The chelicerae serve as cutting organs to permit insertion of the hypostome. They bear two pairs of digits (articles) at their extremities to lacerate the skin of the host. The palps are four-segmented with the fourth segment very small in the hard ticks and approximately equal to the other segments in the soft ticks. The palps do not penetrate the skin of the host. In the hard ticks the mouthparts project from the anterior end of the body, while in the soft ticks they project on the ventral side, hidden dorsally by the body.

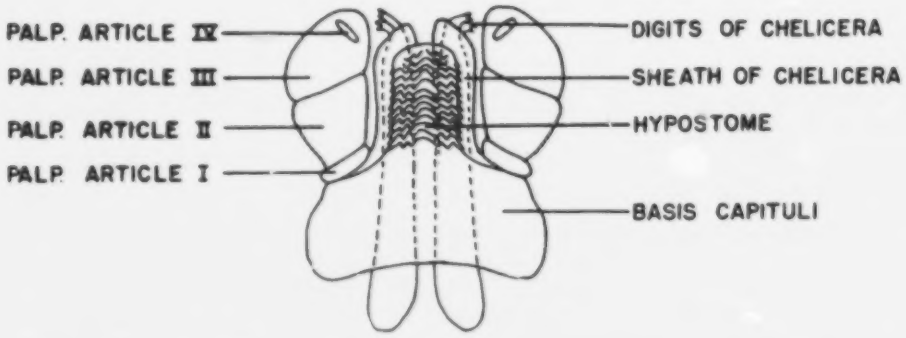


FIGURE 10.3 VENTRAL ASPECT OF CAPITULUM OF A HARD TICK

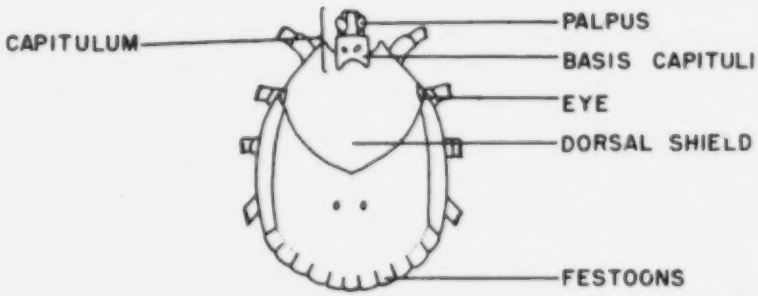


FIGURE 10.4 DORSAL ASPECT OF FEMALE HARD TICK

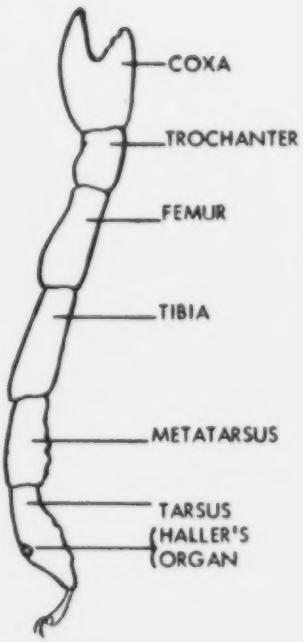


FIGURE 10.5
TICK LEG

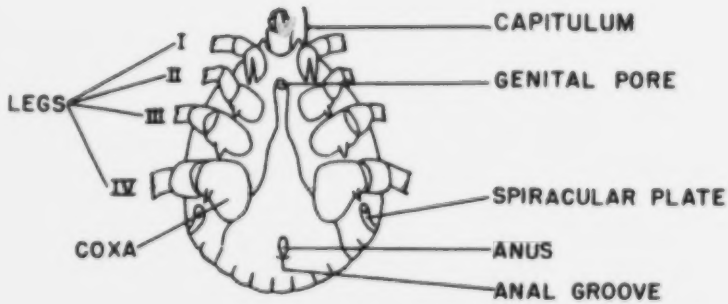


FIGURE 10.6 VENTRAL ASPECT OF MALE HARD TICK

The Body

Ticks have a leathery body covering, or cuticle, that is capable of great distension as they engorge themselves with blood. Before engorgement, female ticks are somewhat flattened and taper toward the anterior end, but after feeding they resemble castor beans. The male hard tick does not become greatly enlarged.

The cephalothorax (head-thorax) is not separated from the abdomen as in the spiders and scorpions. Thus a tick has only one body region (Figure 10.4). Hard ticks have a dorsal shield, or scutum, but soft ticks have none. In the hard ticks this scutum almost covers the male's back but covers less than half of the female's back (Figure 10.7). The scutum becomes quite inconspicuous in engorged females, since it does not become enlarged. When eyes are present in hard ticks they are located on or near the lateral angles of the scutum, and in soft ticks they are on the sides of the body above the bases of the second and third coxae.

Tick larvae have only 3 pairs of legs. The nymphs and adults bear 4 pairs of 6-segmented legs, the segments being called the coxa, trochanter, femur, tibia, metatarsus, and tarsus (Figure 10.5).

The genital pore of the male and female is situated posterior to the mouthparts, lying between the bases of the second pair of legs (Figure 10.6). The genital groove extends backward from the genital pore to the posterior margin of the body in most species. The anus is between the genital grooves and far behind the fourth pair of legs near the posterior end of the body (Figure 10.6). Spiracles are borne in plates just posterior to the bases of the fourth pair of legs in hard ticks (Figure 10.6) and on the sides of the body between the third and fourth coxae in soft ticks. Several of the plates and grooves are of importance in tick identification, see Cooley and Kohls (1945).

INTERNAL MORPHOLOGY

Ticks are adapted for blood-sucking by the presence of a powerful pumping pharynx. After the chelicerae break the skin of the host, the barbed hypostome is thrust deeply into the injury. The salivary glands of some ticks produce a secretion which prevents blood from coagulating. Blood is pumped in by the pharynx and forced backward into the esophagus, stomach, and diverticula attached to the stomach. These sacs become greatly distended to store a large quantity of blood for future use.

Ticks reproduce sexually. The female has a duplex ovary, uterus, and a vagina which leads to the external orifice or genital opening. The male has a similar reproductive system with testes, vas deferens and external opening to produce capsules, or spermatophores, containing many sperm cells.

THE LIFE HISTORY AND HABITS OF TICKS

Ticks have four stages in their life history: egg, 6-legged larva, and 8-legged nymph and adult (Figure 10.7).

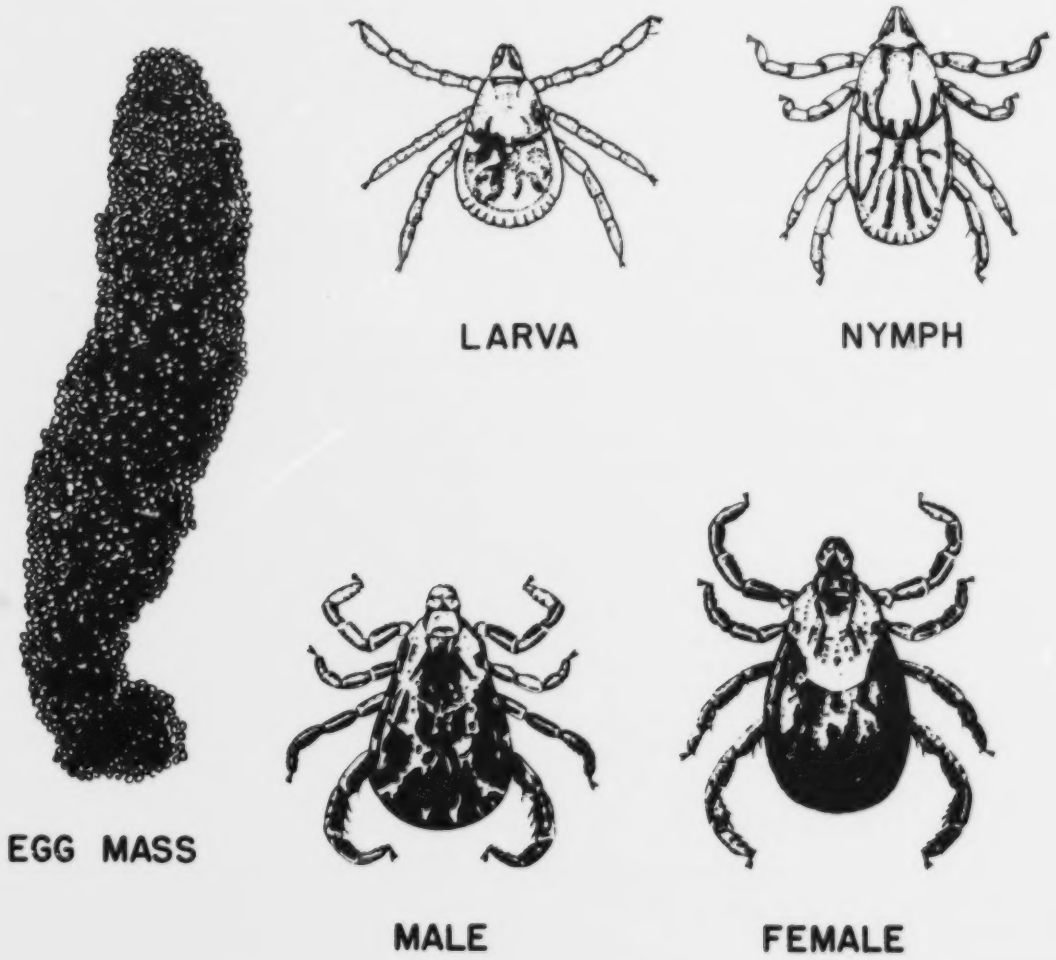


FIGURE 10.7 LIFE HISTORY STAGES OF AMERICAN DOG TICK *(Dermacentor variabilis)*

DEVELOPMENTAL STAGES

The Egg

Mating of hard ticks usually occurs while the ticks are on the host animal. Afterwards the female drops to the ground and deposits eggs on or near the earth. Several days are required for development of the eggs. The female hard tick feeds once and lays one large batch of eggs (Figure 10.7), sometimes 18,000 or more, and dies after oviposition. Most of the soft ticks engorge several times and deposit 20 to 50 eggs in a batch after each blood meal. Eggs hatch in 2 weeks to several months, depending upon temperature, humidity, and other environmental factors.

The Larva

The larvae, or "seed ticks" possess only 6 legs (Figure 10.7) and are not distinguishable as to sex. Their chance of attaching to a host is precarious, making prolonged fasts obligatory.

Despite tolerance to starvation, a very high percentage of larvae fail to survive. Some individuals climb up on vegetation, waiting for a small rodent to pass within reach. Others actively seek a vertebrate host, being guided by the scent of the animal. After a blood meal, the engorged larva usually drops to the soil, sheds its skin, and emerges as an 8-legged nymph. The larva of 1-host ticks remains on the host to molt.

The Nymph

The nymph (Figure 10.7) has 8 legs like the adult but has no genital opening. This stage also must undergo a critical waiting period for a suitable host. After engorgement, the nymph drops from the host, molts, and becomes an adult. Nymphs may rest for long periods of time before becoming adults. Although the life cycle of some species of hard ticks may be completed in less than a year, it may require 2 or 3 years, or longer. Each time a tick leaves its host it risks its survival on the chance that it will find another host. Some species have the advantage of molting on the host. For example, the cattle tick, B. annulatus, is a 1-host tick. Multiple-host ticks are able to exist because of their very great reproductive capacity and their ability to survive for long periods without food.

The hard ticks (Ixodidae) have only one nymphal instar, the nymph becoming an adult after molting. Soft ticks (Argasidae) may have several nymphal instars (Loomis, 1961).

The Adult

Typically the nymph molts after engorgement and becomes an adult (Figure 10.7). Sex then is distinguishable for the first time as the female hard tick differs from the male in having a small scutum. The sex of soft ticks may be determined by the shape of the genital opening located between the second pair of legs. In male soft ticks the genital opening is almost circular, while it is oval, definitely broader than long, in female specimens. Unlike mosquitoes, both male and female ticks

are blood suckers and both require several days feeding before copulation. After the male hard tick becomes engorged, he usually copulates with one or more females and then dies. Following copulation, the female tick drops to the ground and after several days during which the eggs develop she begins oviposition. After a few more days, her life's mission accomplished, the spent hard tick female also dies. The soft tick female may lay several small batches of eggs but she requires a blood meal before each episode of oviposition.

HABITS OF TICKS

Habitats

Hard ticks ordinarily spend much of their long life on the ground or on vegetation awaiting hosts. They are most abundant in shrubby areas, especially along paths, and are scarce in deep woodland. Boophilus species pass most of their time on animals, being 1-host parasites. Generally, hard ticks feed upon three hosts; frequently, but not always, the larvae and nymphs on small mammals or birds and the adults on large mammals. Dermacentor albipictus, a 1-host hard tick, is an exception. The soft ticks feed upon a host only a short time and may be called plural-host ticks.

Climatic Factors

Temperature is an important climatic factor affecting tick development. Unfed hard ticks can endure the frigid winter weather in their sheltered retreats, but engorged ticks and eggs are less resistant. The spring and summer heat induces greater tick activity. Hard ticks can endure long submergence in water and are not injured by humid weather. They usually die quickly in a dry situation, whereas soft ticks generally exist in much drier situations. Table 10.2 gives the distribution of some important species in the United States.

Longevity

Many hard ticks require a year or two to complete their life cycle but may take longer under unfavorable conditions. Loomis (1961) has shown that under optimum laboratory conditions the normal two-year life cycle of Dermacentor andersoni and Amblyomma americanum could be reduced to about 2.5 to 3.5 months. Loomis listed the following approximate time for a complete cycle as follows:

Species	Number of Days for a Complete Cycle
Argas persicus	39-58 days at 32°C.
Otobius megnini	62-118 days at 21-24°C.
Ornithodoros coriaceus	202-314 days at 32°C.
	226-359 days at 25°C.
	364-602 days at 21°C.
Dermacentor andersoni	110-117 days at 21-26°C.
Amblyomma americanum	84-148 days at 21-26°C.

Some ticks are long-lived; specimens of O. turicata having been kept under observation for more than 12 years. Ornithodoros tholozani, an Old World species, is known to have a life span of 20 - 25 years. Ticks are not easily starved out by rotation of cattle pasturage and other cultural measures.

Feeding

Most ticks parasitize a wide range of host animals. Only a few species show a marked preference for feeding upon only one animal species. Ticks feed upon mammals, birds, reptiles, and some amphibians. When feeding, the tick inserts the barbed hypostome into an incision which it has cut with the sharp chelicerae. Most species cause no pain to the host, and the unsuspecting human host may be completely surprised, therefore, when he finds a tick attached on his body. However, some tick species, such as the lone star tick, cause a painful bite. Only females of the hard ticks become greatly distended when engorged, but both sexes of the soft ticks become distended. O. hermsi becomes engorged in 15 to 20 minutes while D. variabilis and most other hard ticks require several days.

Mating

Frequently hard ticks feed and mate on the mammalian host. In some hard ticks the male crawls between the host animal and the female as she is feeding until his genital opening is directly under that of the female. A spermatophore (sperm packet or capsule) is discharged. Then the male distends the vulva of the female with his mouthparts and places the spermatophore in the genital opening. Frequently specimens of the black-legged tick (Ixodes scapularis) are found on deer with males and females copulating in this fashion. Females may mate several times with different males. The mating act of the male hard tick is the prelude to death.

Oviposition

Oviposition by hard ticks requires several days, 14 - 32 for D. variabilis, and 30 - 41 days for D. andersoni. The genital opening is only a short distance behind the mouthparts. The eggs are extruded one at a time and coated with a gelatinous material by a special apparatus called Gene's organ. They are then pushed forward with the mouthparts. Hard ticks typically lay several thousand eggs in a single batch before dying. The largest number of eggs recorded as laid by a single female is 18,000 eggs laid by one Gulf Coast tick (Amblyomma maculatum) reported by Philip (1953). Soft ticks, by contrast, alternate periods of blood-sucking and laying small batches of eggs, producing several hundred to several thousand eggs during their adult lives.

Transmission of Pathogens

Ticks serve both as mechanical and biological carriers of pathogenic organisms. The mouthparts of ticks feeding on infected animals may become

contaminated with the pathogens which are inoculated into healthy animals when the ticks move from one animal to another. This mechanical type of transmission is often called infection through interrupted feeding. In addition, ticks serve as reservoirs of viruses, rickettsiae, spirochetes, bacteria, and protozoa, with transmission of the various pathogens from infected adults through the egg to the following larval, nymphal, and adult stages. This method is often termed transovarial or transstadial transmission of pathogens. Epidemiologically, this last mechanism is of great importance in maintaining the disease-causing organisms in an area during periods of adverse weather conditions such as cold winters or hot, dry summers; in establishing endemic foci of such diseases as Colorado tick fever, spotted fever, relapsing fever, tularemia, cattle tick fever, and anaplasmosis; and in maintaining areas with virulent strains of a pathogen. Infected ticks may require several hours of feeding before sufficient parasites are passed into a susceptible host to cause infection. Therefore, campers and people who work in tick-infested areas should check themselves periodically and remove the ticks as soon after attachment as possible. The feces of infected ticks often contain pathogenic organisms. Some authorities consider that inhalation of dust, including the minute fragments of tick feces loaded with Q fever organisms, is an important method of contracting this disease.

IMPORTANT TICK SPECIES

THE FAMILY IXODIDAE - HARD TICKS

General Characteristics and Habits

The scutum of the hard ticks is one of the chief characters that differentiates them from the soft ticks, which have none (Figure 10.4). In addition, this feature provides a means of immediately differentiating between male and female hard ticks. In the male the scutum is large, completely covering the dorsal surface, while in the female it covers only a part of the dorsal surface and is almost obscured when she becomes engorged. The capitulum of hard ticks extends forward from the anterior end of the body, bearing some resemblance to a true head, while in soft ticks it is found on the under side and is not usually visible from a dorsal view. The spiracles lie behind the fourth pair of coxae (basal segments) (Figure 10.3).

Hard ticks typically take one blood meal in each of the three developmental stages - the larval, the nymphal, and the adult stages. Both sexes are blood feeders, but only the female becomes greatly distended during engorgement. Most species feed on a different host during each stage, but there are some 1-host and 2-host species.

TABLE 10.2 - DISTRIBUTION OF A FEW IMPORTANT TICK SPECIES IN THE UNITED STATES

Scientific Name	Common Name	Distribution
	IXODIDAE - HARD TICKS	
Amblyomma americanum	lone star tick	East of central Texas to Atlantic coast; northward to Iowa
Amblyomma cajennense	Cayenne tick	Southern Texas, southward to Argentina
Amblyomma maculatum	Gulf Coast tick	South Carolina westward to Texas
Boophilus annulatus	cattle tick	South of 37° North Latitude; largely eradicated
Dermacentor albipictus	winter tick	Widely distributed throughout North America
Dermacentor andersoni	Rocky Mountain wood tick	Western states south to northern Arizona and New Mexico
Dermacentor occidentalis	Pacific Coast tick	Pacific coast region
Dermacentor variabilis	American dog tick	East of line drawn from 105th meridian south to western Texas, and in California
Haemaphysalis leporispalustris	rabbit tick	Widely distributed in United States
Ixodes scapularis	black-legged tick	Texas and Oklahoma eastward
Rhipicephalus sanguineus	brown dog tick	Most of United States
	ARGASIDAE - SOFT TICKS	
Argas persicus	fowl tick	Southern tier of states and in a spot in Baltimore
Ornithodoros coriaceus	pajaroello tick	California
Ornithodoros hermsi	Herms' relapsing fever tick	Idaho, Oregon, Washington, California, Nevada, Colorado
Ornithodoros parkeri	Parker's relapsing fever tick	Western states
Ornithodoros turicata	relapsing fever tick	Southern tier of states to Kansas and Oklahoma
Otobius megnini	spinose ear tick	Southwestern and western United States

Genus Amblyomma

Most species of Amblyomma have whitish markings, long palpi, a long hypostome, and festoons on the posterior margin of the abdomen. Only 7 of the more than 90 described species are found in the United States, Amblyomma being more common in the tropics.

THE LONE STAR TICK, Amblyomma americanum, is a vector of spotted fever, tularemia, and possibly Q fever. Female specimens are easily recognized by the conspicuous silvery-white spot at the tip of the scutum (Figure 10.8), hence the name "speck-back" in Ozark mountain region and the common name "lone star tick" for the Lone Star State of Texas which has one star on the state flag. The pale markings are more diffuse on the male specimens. In the southern states east of Texas this species which infests deer, cattle, dogs, and birds. will bite man readily in the larval, nymphal, and adult stages. Its bite is quite painful and may itch for a long time.

THE GULF COAST TICK, Amblyomma maculatum, is found particularly along the Gulf Coast and South Atlantic coastline. It has spurs on the second, third, and fourth pairs of legs and more diffuse pale markings on the female than does the lone star tick (Figure 10.9). When it is present in an area, the ears of cattle will often be found infested. Screw worm flies are often attracted by the smell of fresh blood in these wounds and lay eggs in them. Later the screw worm larvae may feed voraciously, cause festering sores, and even kill cattle.

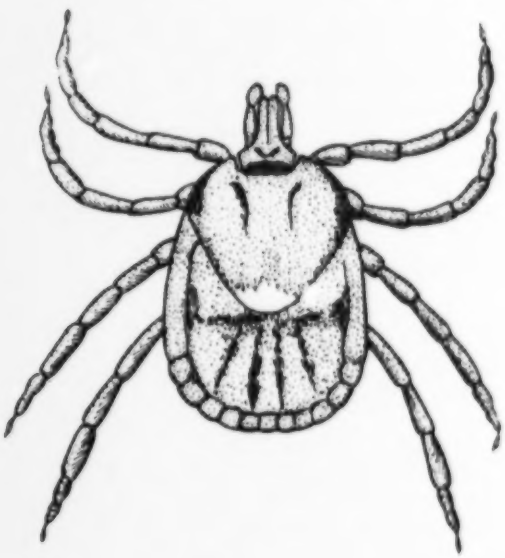


Figure 10.8
Female Lone Star Tick
(Amblyomma americanum)

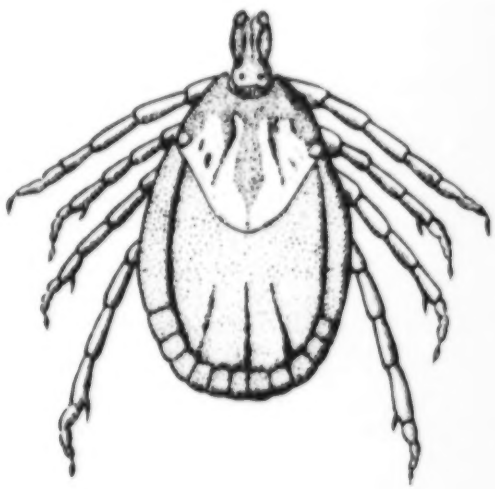


Figure 10.9
Female Gulf Coast Tick
(Amblyomma maculatum)

Genus Boophilus

The genus Boophilus has been eradicated from the United States -- except for small isolated areas in Florida and a narrow zone along the Texas-Mexico border. These ticks are one-host species, the larvae, nymph, and adults all occurring on cattle or deer. They transmit the causative organisms of cattle tick fever and anaplasmosis, passing the Babesia or Anaplasma parasites from infected parent ticks through the eggs to the next generation of larvae, nymphs, and adults. These ticks are recognized by the short palpi with a ridge dorsally and laterally on each segment, the hexagonal basis capituli, and the posterior margin of the abdomen without festoons.

THE CATTLE TICK, Boophilus annulatus, at one time was the most important and common tick attacking livestock in the Southern States. It has been found only occasionally since 1940 in the United States due to the intensive Tick Eradication Program of the U. S. Department of Agriculture.

THE SOUTHERN CATTLE TICK, Boophilus microplus, is also called the tropical cattle tick because it is very prevalent in the West Indies, Central and South America, and tropical Asia and Africa. In the United States it occurs in limited areas in Florida and extreme southern Texas on both cattle and deer.

Genus Dermacentor

The genus Dermacentor comprises the most important group of ticks in the United States as pests of man and his animals, both as blood-sucking parasites and as disease vectors. Some species feed regularly on man and his animals; transmit the causative organisms of spotted fever, tularemia, Colorado tick fever, possibly Q fever, and anaplasmosis; and pass many of the causative agents of these diseases transovarially and transstadially. Specimens of D. variabilis and D. andersoni are the ticks most frequently involved in cases of tick paralysis in this country. Dermacentor ticks are ornate (i.e., they have pale markings on the scutum) with eyes and 11 festoons, the palpi short, and the basis capituli quadrangular dorsally.

THE AMERICAN DOG TICK, Dermacentor variabilis, is widely distributed east of the Rocky Mountains and also occurs on the Pacific Coast. This tick will be discussed somewhat in detail as a representative of the hard ticks, following the account of Smith, Cole and Gouck (1946).

The dog is the preferred host of adult D. variabilis, although it feeds readily on many of the large mammals. The adult ticks are commonly found in the spring in their "waiting position", on grass and other low vegetation. The third pair of legs is used to cling to the grass while the others are waved about ready to grasp any host that comes by. The male remains on the host for an indefinite time, alternately feeding and mating. The female feeds, mates, becomes engorged, and drops off to lay several thousand eggs. The larval ticks are very tiny and have but 6 legs.

MALE FEMALE

FIGURE 10.10 American Dog Tick (Dermacentor variabilis) (After USDA)

The adult males and females are frequently encountered by sportsmen and people who work out-of-doors. The males and females have pale whitish or yellowish markings on the scutum as shown in Figure 10.10. Males may be only 1/8 inch long, while engorged females may be as much as 1/2 inch in length.

Larval activity begins in March or April in Massachusetts, ceasing in September or October. Larvae seek the host actively, and do not assume the waiting position typical of the adults. They are not captured by means of drags. Meadow mice, white-footed mice, and pine mice are important hosts of larvae.

Males of D. variabilis do not feed to an extent that alters their size noticeably. Females may increase in size from about 5 mm. long and 2.5 mm. wide to 13 mm. long and 10 mm. wide but their engorgement is retarded if males are not present. The newly-hatched larvae are about 0.6 mm. long without spiracular plates, and are yellow with red markings near the eyes. Engorged larvae are about 1.5 mm. long and are slate gray to black. Nymphs are similar in appearance to the larvae, but have 4 pairs of legs and a pair of spiracular plates. Unfed nymphs are about 1.5 mm. long, and are light yellowish brown with red markings near the eyes. Engorged specimens are slate gray and about 4 mm. in length. The entire life cycle requires from 4 months to more than a year.

American dog ticks, as well as other species, are attracted by the scent of animals, hence are most numerous along roads, paths, and trails. Engorged ticks that drop from animals using the passageways further increase the concentration at these sites. These facts are important to persons applying insecticides for tick control.

THE ROCKY MOUNTAIN WOOD TICK, Dermacentor andersoni, is found in the Rocky Mountain states and in southwestern Canada. The life cycle of this 3-host tick requires 2 to 3 years for completion. The larvae and nymphs attack small mammals and the adults obtain their blood meals from large mammals including man. The range of this tick coincides with the area in which cases of Colorado tick fever are contracted. It is rather similar to the American dog tick discussed previously, but adults of the wood tick in general have more pale coloring, and larger goblets on the spiracular plates, than does the American dog tick.

THE WINTER TICK, Dermacentor albipictus, is a 1-host species parasitic on cattle, horses, moose, elk, and deer. These ticks are sometimes extremely abundant on these large animals and may cause such serious loss of blood that anemia and even death result from their attacks. The spiracular plates are oval with very large goblets.

THE PACIFIC COAST TICK, Dermacentor occidentalis, is a 3-host tick whose life cycle on small rodents and large mammals may be completed in less than 3 months. It is a serious pest of cattle at all times in the year and will attack man. It is a known vector of tularemia and a suspected vector of Rocky Mountain spotted fever. The basis capituli has conspicuous tooth-like projections on the posterior margin known as cornua.

Genus Haemaphysalis

This genus includes small inornate ticks without eyes but with festoons. It is most easily recognizable by the second article of the palpus being produced laterally.

THE RABBIT TICK, Haemaphysalis leporispalustris, is a 3-host tick which may help in maintaining the reservoir of spotted fever and tularemia in wild rodents. It is found in all of the states in continental United States, including Alaska.

Genus Ixodes

Ticks in the genus Ixodes are easily recognized by the position of the anal groove, which lies in front of the anus and extends from one side of the body to the other. There are 34 species of ticks in the genus Ixodes in North America, more than in any other genus (see checklist p.37). Male specimens have a complicated arrangement of plates on the ventral side of the abdomen as shown in the excellent paper by Cooley and Kohls (1945). Most species have enlarged club-like palps.

THE BLACK-LEGGED TICK, Ixodes scapularis, occurs in the eastern half of the United States. Male and female specimens are frequently found mating on deer, dogs, and other large mammals in the fall and winter. This species will feed on man.

THE PACIFIC TICK, Ixodes pacificus, is the western counterpart of I. scapularis and both species are related to the castor-bean tick of the Old World, Ixodes ricinus. I. pacificus adults will bite deer, cattle and man readily.

Genus Rhipicephalus

Many species of ticks in the genus Rhipicephalus occur in Africa and Asia where they are important vectors of disease to man and animals. These ticks have a hexagonal basis capituli, eyes on the scutum, and festoons on the posterior margin of the abdomen. Male specimens are distinguished from most other common ticks by the adanal plates and accessory plates on either side of the anus.

THE BROWN DOG TICK, Rhipicephalus sanguineus is a reddish-brown species that attacks dogs, but rarely man. It is not known to transmit human diseases in the United States although it is a known vector of Marseilles fever in the Mediterranean Region. The ticks are most frequently attached to the ears and between the toes of dogs. This species is one of the most common in homes, where it feeds on dogs and then drops off the infested animal. The engorged female specimens, sometimes about a half inch long, are particularly noticeable as they crawl on walls or around baseboards and cracks, looking for protected areas in which to deposit 1000 to 3000 eggs.

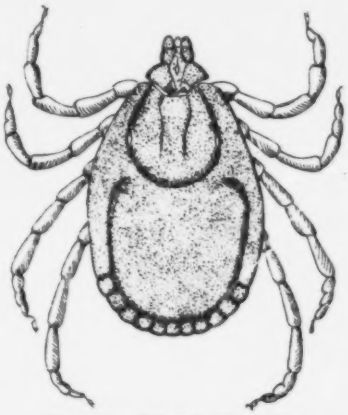


Figure 10.11 Female Brown Dog Tick (Rhipicephalus sanguineus)

The entire life cycle of this species can be completed in less than two months. In the South, this species occurs in buildings, kennels and small animal hospitals, and outdoors in yards. In the North, this tick is rarely found outdoors. It is a very difficult and important species to control.

THE ARGASIDAE - SOFT TICKS

General Characteristics and Habits

The sexes are similar in soft ticks, there being no hard dorsal plate (scutum). The capitulum which bears the mouthparts is located beneath the anterior margin of the body. The spiracles or respiratory openings lie on the sides of the body above the third and fourth pairs of legs. Although some species of soft ticks feed upon humans, they are more common on birds, and occasionally are found on bats and other small mammals. The sexes can

be distinguished by the shape of the genital opening which in males is circular or crescent-shaped and in females is a transverse slit wider than long.

Soft ticks are typically intermittent feeders and can survive long periods without food. Some species resemble bed bugs in their habits of feeding at night and hiding in cracks and crevices during the day.

Genus Argas

Ticks of the genus Argas have the margin of the body flattened and show a sutural line, somewhat like a pie-crust edge, definitely dividing the body into dorsal and ventral surfaces (Figure 10.12).

THE FOWL TICK, Argas persicus, which is often called the "blue bug" in the South, is a vector of fowl spirochetosis. Occasionally this species attacks poultry workers. Both males and females of this species feed at night and become engorged in less than an hour. After feeding they seek shelter in cracks and crevices where the female deposits her eggs. The eggs hatch in 2 weeks or more, and the 6-legged larvae find a host and attach themselves. After about 5 days feeding, they drop off, shed, and become nymphs. The nymphs feed, molt, and go through two or three stages to become adults. The entire life cycle requires a minimum of 30 to 40 days if food and temperature are suitable, but frequently the time is much longer.

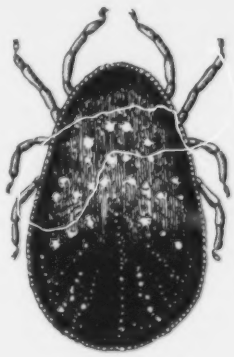


Figure 10.12 - The Fowl Tick (Argas persicus)

Genus Ornithodoros

Ornithodoros is the most important of the four genera of soft ticks. The ticks in this genus have a more globular body without the sutural line found in the various species of Argas. The body is roughened or warty in appearance with tiny protuberances which Cooley and Kohls (1944a) have termed "mammillae". At least 14 species are known in the United States including Alaska and Hawaii (see Checklist, p. 38), of which four are known vectors of relapsing fever in the United States.

THE RELAPSING FEVER TICKS, Ornithodoros species, are seldom seen by the average person since they are primarily "nest ticks" which can survive starvation for months or even years. Human beings are occasionally bitten by these hungry ticks and contract cases of relapsing fever in mountain cabins, caves, or wild animal burrows. For example, O. hermsi is found at high elevations in the West where it parasitizes small mammals such as

TABLE 10.3 - SOME IMPORTANT TICK SPECIES AND THEIR HOSTS

Genus	Species	Common Name	Common Hosts
		IXODIDAE - HARD TICKS	
Amblyomma	americanum	lone star tick	livestock, dog, deer, birds, man
Amblyomma	cajennense	Cayenne tick	livestock, deer, dog, man
Amblyomma	maculatum	Gulf Coast tick	livestock, deer, birds, dog, man
Boophilus	annulatus	cattle tick	livestock, deer
Dermacentor	albipictus	winter tick	large domestic and wild animals, man
Dermacentor	andersoni	Rocky Mountain wood tick	livestock, wild mammals, man
Dermacentor	occidentalis	Pacific Coast tick	wild mammals, livestock
Dermacentor	variabilis	American dog tick	dogs, small mammals, large mammals, man
Haemaphysalis	leporispalustris	rabbit tick	rabbits, small mammals, birds
Ixodes	scapularis	black-legged tick	mammals, birds, man
Rhipicephalus	sanguineus	brown dog tick	dogs, other mammals
		ARGASIDAE - SOFT TICKS	
Argas	persicus	fowl tick	fowl
Ornithodoros	coriaceus	pajaroello tick	mammals, man
Ornithodoros	hermsi	Herms' relapsing fever tick	chipmunk, man
Ornithodoros	parkeri	Parker's relapsing fever tick	man, rodents
Ornithodoros	turicata	relapsing fever tick	man, rodents, hogs
Otobius	megnini	spinose ear tick	livestock, large wild mammals, man

the western chipmunk (Eutamias) or tree squirrels (Tamiasciurus). People sleeping in mountain cabins occasionally come in contact with infected ticks and contract the disease relapsing fever (Herms and James, 1961). O. parkeri, a large species found in nine western states, is an efficient vector of relapsing fever and can transmit Rocky Mountain spotted fever. O. turicata, also a large tick, is found in the West and in the South in caves, holes made by burrowing animals, and at camp sites, and its host include rodents, snakes, terrapins, and various domestic animals, as well as man. Even after long starvation it too, is an efficient vector of relapsing fever. Both turicata and parkeri transmit the spirochete of this disease to their offspring, the latter species as far as the fourth generation. O. talaje occurs in southern United States.

THE PAJAROELLO TICK, Ornithodoros coriaceus, is found in California where it attacks both deer and man. Herms and James (1961) report that the bite of this tick is "more feared than the rattlesnake by persons living where it exists." In one case following tick bite the leg became numb and lesions exuded clear lymph from beneath a scab for several weeks. Loomis (1961) recorded the life history as requiring 200 to 600 days,
see page X-13.

Genus Otobius

The integument of the adults is granular while that of nymphs is spinose. The hypostome of adult Otobius has no teeth, one means of separating these ticks from species of Ornithodoros.

THE SPINOSE EAR TICK, Otobius megnini, receives its name from the fact that the larvae and nymphs are found in the ears of cattle, horses, mules, sheep, cats, dogs, and rarely man. Cats which have died from an unknown malady have been found with engorged spinose ear nymphs firmly embedded in the ear. This is a 1-host tick: the larvae and nymphs feed on the same host; the full-grown nymphs drop off the host to molt, and the adults mate and the female lays a batch of eggs without another blood meal. The organisms of Q fever have been found in the spinose ear tick but is not known to transmit this disease to humans at present.

CONTROL OF TICKS

PROTECTION FOR HUMANS

Mechanical Means. The individual may obtain some degree of protection against ticks by keeping his clothing buttoned and by tucking his trouser legs into the tops of his socks and his shirttail into his trousers. He should avoid sitting on the ground or on logs in brushy areas. Inspecting the clothing and the body and removing ticks before they attach will protect against exposure to tick paralysis and various tick-borne diseases. Clearing or burning brush along paths and keeping weeds and grass cut in recreation areas reduces the likelihood of tick infestation. In residential areas closely-cut lawns and well-kept yards help control both the ticks and their small rodent hosts.

If ticks become attached, the simplest method of removing them is by a slow steady pull that will not break off the mouthparts and leave them in the wound. There is no certain way to make a tick detach its mouthparts. A drop of chloroform, carbon tetrachloride, ether, benzene, or vaseline or fingernail polish rubbed over it, will help remove the tick. Several minutes to a half-hour later, when the tick has withdrawn its mouthparts, it can be removed with less damage to the skin. Touching a lighted end of a cigarette sometimes causes it to release attachment. An antiseptic should always be applied to tick bites just as to other open wounds. If the hands have touched the tick during removal, wash them thoroughly with soap and water since the tick secretions may be infective.

Dermacentor spp. have a comparatively short hypostome and are rather easily removed, while Amblyomma and Ixodes have longer mouthparts, penetrate more deeply - even through socks - and are difficult to remove.

Tick Repellents

Many repellents have been tested against ticks, but no general chemical for all species is known. The application of a repellent to exposed skin provides little protection against ticks since they crawl underneath clothing and attach on untreated portions of the body. The applications of repellents to the entire body might prevent attachments for a few hours, but such extensive treatments are impracticable and might prove injurious. For these reasons, clothing treatments with repellents are suggested instead of skin treatments. Indalone, diethyl toluamide, dimethyl carbate, dimethyl phthalate, and benzyl benzoate provide up to 90 percent protection. The repellency of M-1960, the present military clothing treatment, to ticks is due primarily to the presence of butylacetanilide, although the benzyl benzoate and butyl ethyl propanediol are also moderately good tick repellents. Clothing should be saturated with a solution or emulsion of the repellent by dipping the garment into it or by pouring enough to saturate it. A 5 percent solution or emulsion will give a deposit of about 2 grams a square foot on denim, ordinary cotton khaki, or light wool clothing. About 3 pints are required to wet thoroughly a complete outfit of socks, shirt, and trousers of these fabrics. Further details are given in the paper by McDuffie and Smith (1955). After the clothing has been wetted, it should be wrung out by hand, hung up outdoors, and allowed to dry thoroughly before it is worn. Properly treated clothing will provide good to excellent protection against ticks, as well as chiggers and mosquitoes, for several days to a week if it is not subjected to wetting by rains or by wading in streams or lakes. Clothing should be thoroughly washed and re-treated at weekly intervals or before infrequent outdoor excursions.

CONTROL OF TICKS ON DOMESTIC ANIMALS

Dogs and cats may be freed of ticks by using a liquid or a dust containing about 0.75 to 1 percent rotenone, or dusts containing 3 to 5 percent malathion. Dogs, but not cats, may also be treated with dusts containing 1 percent lindane, 2 to 3 percent chlordane, or 5 percent DDT. Diazinon and dieldrin should never be used in treating these animals. In controlling brown dog ticks resistant to the chlorinated hydrocarbons, malathion dust has given moderately good control. Frequent treatments of both the pet and the infested area are necessary before an infestation is cleared up. Often it is necessary to launder or destroy the animal's bedding. Hand picking, or combing out, of ticks gives satisfactory results when infestation is light.

A new development in the control of ticks and other ectoparasites on dogs is the use of one of the less toxic organic phosphorus insecticides, ronnel, as a systemic insecticide. In pill form this is sold only by or on the order of a licensed veterinarian. For a 10 pound dog, one 500 milligram tablet is administered every 2 days for 4 treatments, then 1 tablet weekly thereafter to prevent reinfestation. Dogs weighing 20 or more pounds may require 2 or more times this dosage to maintain the proper blood level of the chemical in milligrams per kilogram necessary to kill the ectoparasites.

For controlling ticks on horses, cattle, sheep, and goats the U. S. Department of Agriculture (1962) recommends dips or sprays of the following insecticides:

TABLE 10.4 INSECTICIDES FOR CONTROLLING TICKS ON LIVESTOCK
(USDA, 1962)

Insecticide	Formulation	Safety Precautions
Co-Ral	0.25% Suspension	Do not use lindane on emaciated or
Delnav	0.15% Emulsion	lactating animals, or Co-Ral, DDT,
Lindane	0.03% Emulsion or Suspension	Delnav, malathion, ronnel, or toxaphene on milk goats.
Malathion	0.5% Emulsion or Suspension	Do not treat animals less than 3
Ronnel (Korlan)	0.25 to 0.5% Emulsion or Suspension	months old with Co-Ral; spray animals 3-6 months old lightly; do not use
Toxaphene	0.25 to 0.5% Emulsion or spray	with pyrethrins, allethrin, or synergist.
		Do not use malathion on animals less than 1 month old.

In applying insecticides to livestock or around barns, do not contaminate feed or feed and water troughs, or allow runoff into streams. Observe all other precautions on insecticide containers.

For controlling the fowl tick, the U. S. Department of Agriculture (1962) recommended 0.5 percent chlordane or toxaphene, 0.5 percent DDT outdoors, or 3 percent malathion indoors, as residual sprays at a rate of one to two gallons per 1000 square feet. The applications should be made to chicken houses, roosts, and similar hiding places of the ticks.

CONTROL OF TICKS IN BUILDINGS

The brown dog tick, R. sanguineus, frequently causes severe annoyance to man by invading homes and other buildings and by infesting domestic pets. It is a major pest in many small animal hospitals. The American dog tick and other species will also come into dwellings on pets. Chlorinated hydrocarbon insecticides such as 5 percent DDT, 3 percent chlordane, and 0.5 percent dieldrin or lindane are effective in killing non-resistant brown dog ticks and most specimens of Dermacentor, Amblyomma, and Ixodes. In many areas, however, the brown dog tick has developed resistance to the chlorinated hydrocarbon insecticides so residual applications of the organic phosphorus insecticides, 0.5 percent diazinon or 1 percent malathion, give effective control for up to 12 weeks. These insecticides may be applied as emulsions or in solutions of deodorized kerosene. In treating homes, DDT may be applied to broad areas, but the other pesticides should be employed only as spot treatments to baseboards, floor and wall crevices. and other harborage sites. The addition of 0.2 to 0.5 percent DDVP to these sprays is often beneficial since it acts as a fumigant in "flushing out" ticks hiding behind baseboards, in cracks, or in masonry walls. With severe infestations of the brown dog tick, it may be necessary to retreat both the building and the pet.

CONTROL OF TICKS IN VEGETATED AREAS

Area control of ticks can be obtained by the application of DDT, chlordane, dieldrin, and toxaphene at rates of 1 to 2 pounds of actual insecticide per acre, or of BHC at 0.5 pound of the gamma isomer per acre (Communicable Disease Center, 1962). Dust, suspension, or emulsion formulations of these insecticides produce similar results. Dusts are applied by airplane or by hand or power ground equipment. Correct application rates of the first four insecticides above would be 10 to 20 pounds of the 10 percent dust, or 20 to 40 pounds of the 5 percent dust, per acre. Good control has also been obtained with 15 to 20 pounds of the agricultural dust containing 3 percent gamma isomer of BHC, particularly near ponds and streams where the application of the first four insecticides at maximum dosages may prove highly toxic to fish. Suspensions are often applied with orchard sprayers. With DDT, for example, use 2 to 4 pounds of 50 percent wettable powder per acre in 25 to 100 gallons of water, depending on type of terrain, from lawns to dense brushy areas. Emulsions are generally applied with mist blowers. It is wise to use a large volume of low percentage emulsion, rather than a small volume of high percentage spray, to insure adequate coverage and decrease the hazard of "burning" vegetation with emulsion solvents. In some areas the U. S. Department of Agriculture (1962) has recommended as high as 4 lbs. of DDT actual insecticide per acre.

The various tick species differ in their susceptibility to DDT. For example, the lone star tick has been controlled for several months with applications of only one pound of DDT dust per acre. Larvae seems to be more susceptible than nymphs and adults. Control is not immediate and ticks often increase after several weeks.

CONTROL BY REMOVAL OF HOSTS

In cases where homes are severely infested with brown dog ticks that show resistance to insecticides, removal of the dog is sometimes the only means of control since these animals are normally the chief source or the only source of blood meals for this species.

Cattle tick infestations may be reduced by rotation of pastures. No control method replaces dipping, spraying, or dusting of cattle, dogs, or other hosts. Animals that are heavily infested with engorged ticks can seed an area rapidly due to the tremendous reproductive rate of these arthropods. It is best to keep dogs away from heavily infested areas, if possible, or to treat them promptly if they become infested.

Field rodents that are hosts of ticks can be controlled with poisoned baits (warfarin, pival, zinc phosphide, strychnine, etc.) or by other rodent control techniques. In the western mountains, the chipmunk hosts of Ornithodoros ticks should be eliminated in and around cabins by trapping, poisoning or rodent proofing with masonry, sheet metal or hardware cloth.

TICK SURVEYS AND IDENTIFICATION

Tick surveys are valuable in determining (1) what species are present, (2) whether or not ticks are infected, (3) whether control is needed, and (4) the results obtained from control efforts.

TICK SURVEY METHODS

Ticks can be picked from the host animal in order to determine the infesting species and its prevalence. For more comprehensive surveys, a tick drag may be used; but this method of collection will yield largely the nymphal and adult stages since the larvae do not generally attach to the cloth. The drag is made of a white flannel cloth approximately 1 yard wide by 1-1/2 yards long attached to a yard-long stick, and a cord may be fastened to the ends of the stick to facilitate dragging. The cloth is pulled slowly along over low vegetation beside roads and paths, allowing the waiting ticks to attach themselves. A specified distance for dragging, say 50 feet, may be established so that sample will be comparable. When the drag has been pulled this distance, the ticks are picked from the cloth immediately and dropped into vials containing 70 to 80 percent alcohol. If slides are to be made, the live ticks are killed and preserved in 70 to 80 percent alcohol, cleared in potassium hydroxide, dehydrated in absolute alcohol, cellosolve, and olive oil and mounted in balsam or some other suitable media.

TICK IDENTIFICATION

There are approximately 75 species of ticks in the 50 states now comprising the United States, 55 hard ticks in the family Ixodidae and 20 soft ticks in the family Argasidae. The genera of ticks can be determined with the "Pictorial Key to Genera of Adult Ticks in the United States" (p. X-30). The most common species of ticks that affect man and his animals can be determined with the "Pictorial Key to Some Common Adult Ticks" (p. X-31), or with the "Illustrated Key to Some Common Adult Ticks" (pp. X-32 - X-36). People interested in detailed studies on tick taxonomy should use some of the literature cited in the "Check List of Ticks Found in the United States" (pp. X-37 and X-38), or the "Selected References" (pp. X-39 - X-42). This check list was kindly checked in the spring of 1961 by Glen M. Kohls, Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Montana.

Ticks can be identified by the use of pictorial and couplet keys using the external structures of ticks discussed and figured on pages X-8 to X-10.

The pictorial keys on pages X-30 and X-31 illustrate the position of the capitulum in hard and soft ticks, the Ixodidae and Argasidae. To use these keys a choice must be made, depending upon this one character. Other characters are used in a similar manner to work downward on the key to the correct generic or specific name of the tick.

The couplet (or dichotomous) key on pages X-32 to X-36 is more typical of the usual identification keys found in reference works and scientific papers. There are couplets of statements numbered on the left margin. Starting with couplet 1 there are in each case two descriptive statements only one of which will apply to the specimen being identified. The number on the right following the correct statement refers to the next couplet to be considered, which will again offer two choices. This method is continued until the correct identification has been made.

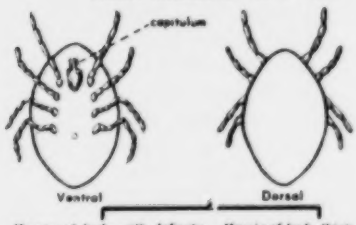
In detailed survey work using technical literature listed on pages X-37 and X-38, different keys are used for males, females, nymphs, and adults.

Ticks are usually preserved for study in 70 percent alcohol and examined with the aid of a microscope lamp and a dissecting microscope. In addition, for many years in training classes, the authors have used ticks mounted with adhesive or "Scotch" tape on glass slides. These preparations are inexpensive, easily prepared, and have lasted for many years. They have been most useful in showing students the simple characters used in distinguishing soft and hard ticks, and the more obvious structures or color patterns by which the common species of ticks are identified.

PICTORIAL KEY TO GENERA OF ADULT TICKS IN UNITED STATES

By Harry D Pratt

Capitulum inferior; scutum absent
FAMILY ARGASIDAE – SOFT TICKS



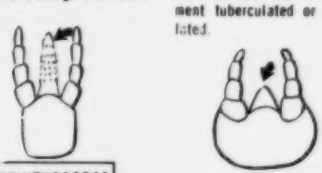
Margin of body with definite sutural line.

Margin of body thick, rounded, without definite sutural line.

ARGAS

Hypostome with well developed teeth, integument mamillated

Hypostome vestigial or without effective teeth. Integument tuberculated or granulated.



ORNITHODOROS

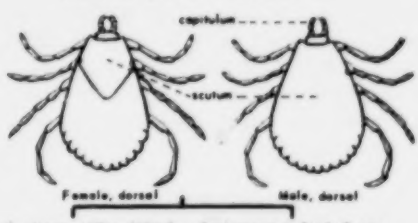
Integument of adult granular, of nymph (stage usually seen) very spinose. Hypostome of adult vestigial. Usually on cattle, horses, or rabbits.

Integument of adult and nymph tuberculated. Hypostome of adult scoop-like. Associated with bats.

OTOBIUS

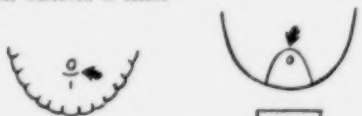
ANTRICOLA

Capitulum anterior; scutum present
FAMILY IXODIDAE – HARD TICKS



Anal groove either behind anus, indistinct, or absent.

Anal groove in front of anus.



IXODES

Second segment of palpi not laterally produced.

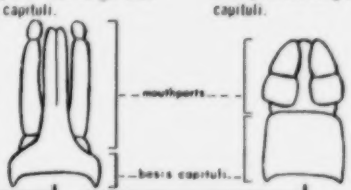
Second segment of palpi laterally produced.

HAEMAPHYSALIS

Mouthparts much longer than basis capituli.

Mouthparts as long as basis capituli.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, CDC
ATLANTA, GA., AUGUST 1961

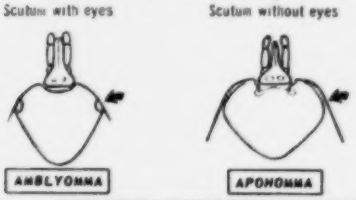


Scutum with eyes

Scutum without eyes

Basis capituli laterally produced.

Basis capituli not laterally produced.



AMBLYOMMA

APONOMMA

Palpi ridged dorsally and laterally.

Festoons absent.

Palpi not ridged.

Festoons present.

Festoons eleven

Festoons seven

BOOPHILUS

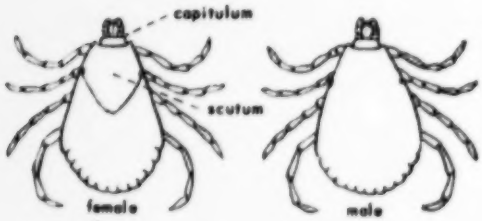
RHIPICEPHALUS

DERMACENTOR

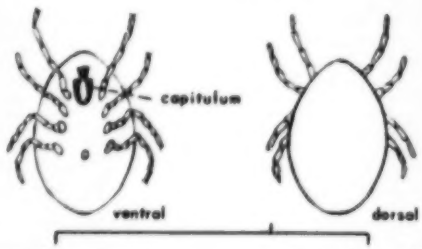
ANOCENTOR (OTOCENTOR)

PICTORIAL KEY TO SOME COMMON TICKS

capitulum visible from above, scutum present, family Ixodidae, HARD TICKS



capitulum not visible from above, scutum absent, family Argasidae. SOFT TICKS



sutural line present

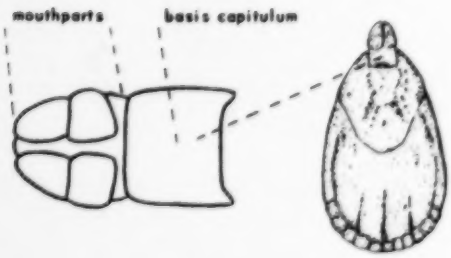
Argas persicus
FOWL TICK

sutural line absent

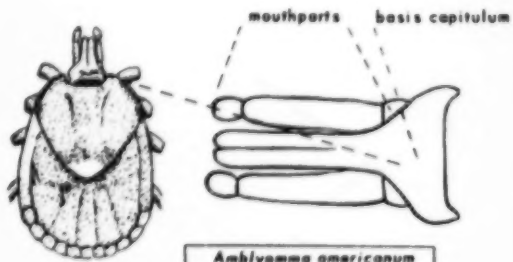
Ornithodoros
RELAPSING FEVER TICK

PREPARED BY H. D. PRATT
U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE, CDC
ATLANTA, GA., MARCH 1961

mouthparts short, about as long as basis capituli

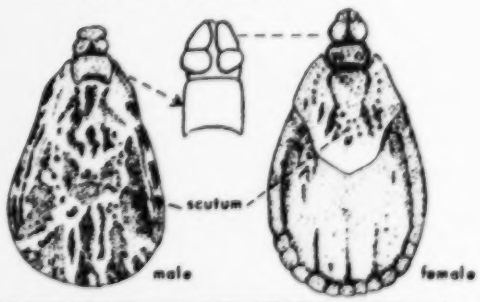


mouthparts much longer than basis capituli
white spot on tip of scutum of female



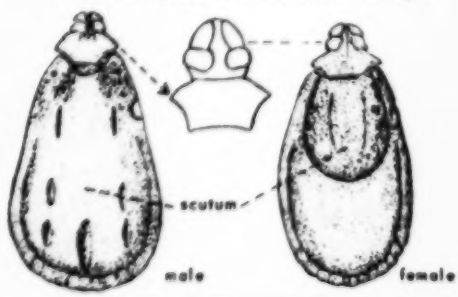
Amblyomma americanum
LONE STAR TICK

scutum with white markings; basis capituli with parallel sides



Dermacentor variabilis and *D. andersoni*
AMERICAN DOG TICK AND WOOD TICK

scutum without white markings; basis capituli produced laterally to form an angle



Rhipicephalus sanguineus
BROWN DOG TICK

ILLUSTRATED KEY TO SOME COMMON ADULT TICKS

1. Capitulum at anterior end of body, visible from above and below; scutum or dorsal shield present, short in female, long in male (Fig. 1 A & B). Family Ixodidae..HARD TICKS....2

   Capitulum on under side of body, hidden by body when seen from above though palpi may project anteriorly; scutum absent (Fig. 1 C & D). Family Argasidae.....SOFT TICKS....10

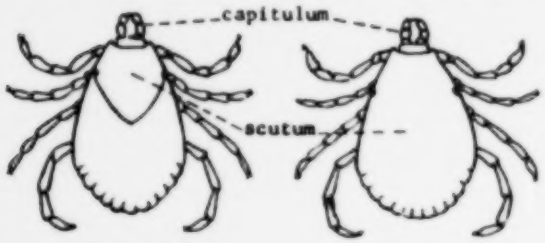


Fig. 1 A

Fig. 1 B

Fig. 1 C

Fig. 1 D

FAMILY IXODIDAE - HARD TICKS

2. Ornate ticks, with some white markings on dorsal shield (Fig. 2 A).....3

   Inornate ticks, without white markings on dorsal shield (Fig. 2 B).....8

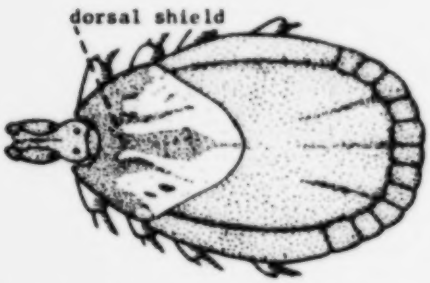


Fig. 2 A

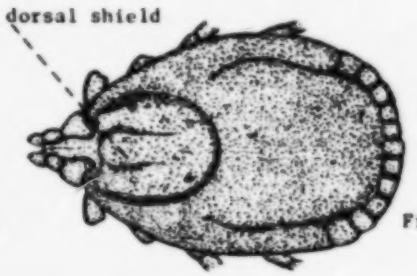


Fig. 2 B

3. Palpi long, much longer than basis capituli; second segment of palpus about twice as long as wide (Fig. 3 A). Genus Amblyomma.....4

   Palpi short, about as long as basis capituli; second segment of palpus about as long as wide (Fig. 3 B). Genus Dermacentor.....5

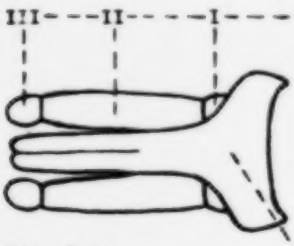


Fig. 3 A

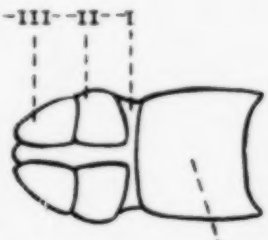


Fig. 3 B

4. Next to last segment of second, third, and fourth pairs of legs without paired terminal spurs; female with a distinct pale marking near posterior end of dorsal shield (Fig. 4 A). Amblyomma americanum.....LONE STAR TICK

Next to last segment of second, third, and fourth pairs of legs with long, paired terminal spurs; female with more diffuse markings on dorsal shield (Fig. 4 B)..... Amblyomma maculatum.....GULF COAST TICK

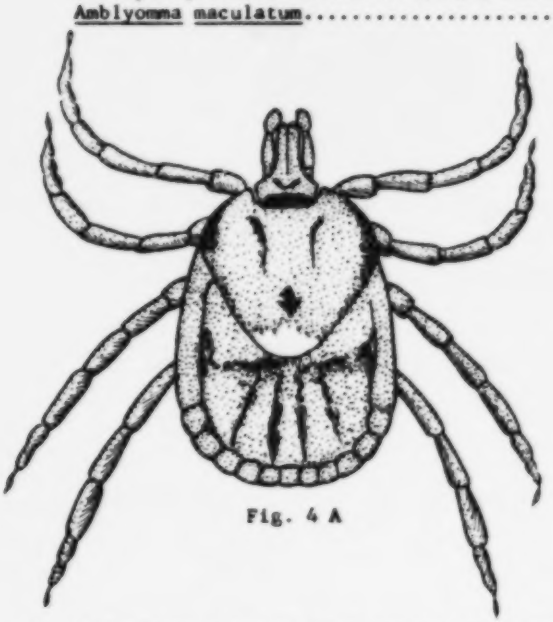


Fig. 4 A

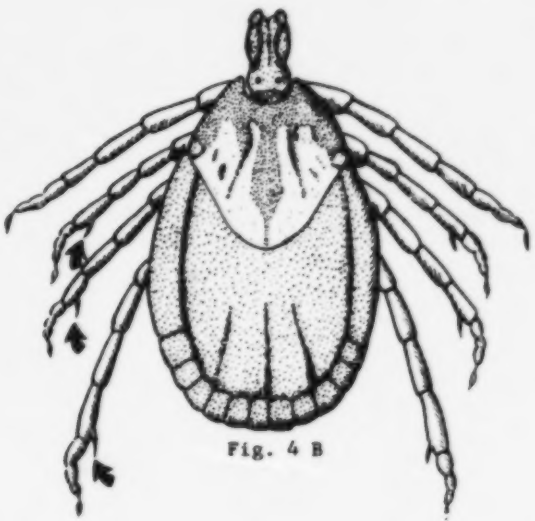


Fig. 4 B

5. Spiracular plate without dorsal prolongation (Fig. 5 A). Dermacentor albipictus..... .....WINTER TICK

Spiracular plate with dorsal prolongation (Fig. 5 B).....6

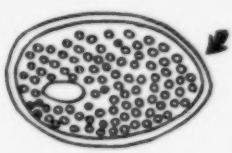


Fig. 5 A

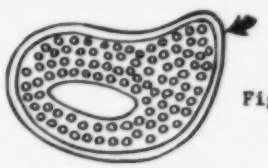


Fig. 5 B

6. Basis capituli with long cornua (Fig. 6 A). Dermacentor occidentalis.PACIFIC COAST TICK

Basis capituli with short cornua (Fig. 6 B).....7

Fig. 6 A

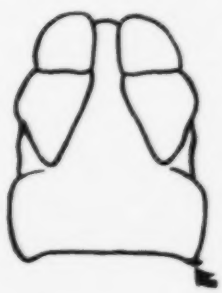


Fig. 6 B

7. Goblets of spiracular plate large and less numerous; Rocky Mountain species. (Fig. 7 A) Dermacentor andersoni.....ROCKY MOUNTAIN WOOD TICK

Goblets of spiracular plate very small and numerous; east of the Rocky Mountains and on the Pacific coast. (Fig. 7 B). Dermacentor variabilis.....AMERICAN DOG TICK

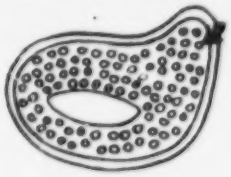


Fig. 7 A

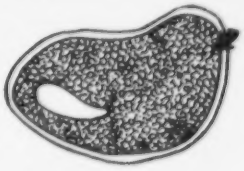


Fig. 7 B

8. Sides of basis capituli laterally produced; distinctly angulate; eyes present on sides of scutum (Fig. 8 A & B).....9

Sides of basis capituli not laterally produced; more or less parallel (Fig. 7 C); eyes absent.....10

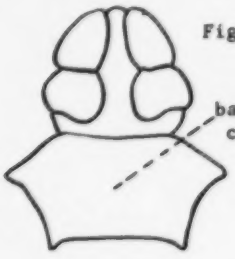


Fig. 8 A

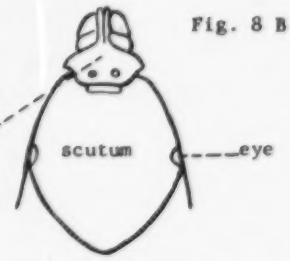


Fig. 8 B

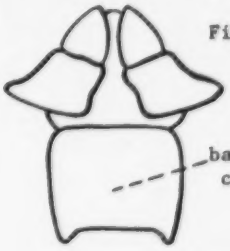


Fig. 8 C

9. Fore coxa deeply cleft; festoons present; easily seen in unengorged specimens; anal groove distinct in unengorged specimens (Fig. 9 A). (principally on dogs or in houses) Rhipicephalus sanguineus.....BROWN DOG TICK

Fore coxa not deeply cleft; festoons absent; anal groove indistinct (Fig. 9 B). (On cattle and deer). Boophilus annulatus.....CATTLE TICK

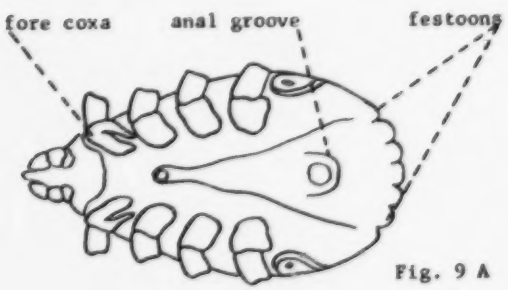


Fig. 9 A

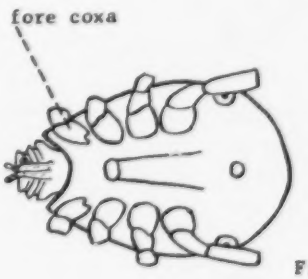


Fig. 9 B

10. Second segment of palpus laterally produced; anal groove behind anus, not attaining posterior margins of body (Fig. 10 A & B). Haemaphysalis leporispalustris.....RABBIT TICK

Second segment of palpus not laterally produced; anal groove extending as an inverted U from in front of anus to posterior margins of body (Fig. 10 C).....Genus Ixodes

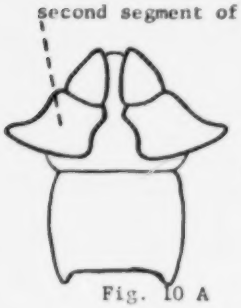


Fig. 10 A

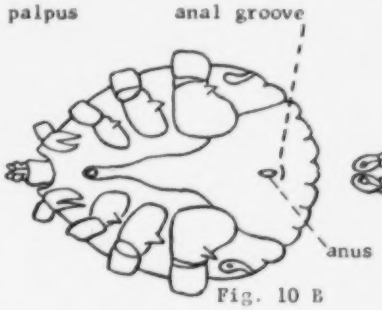


Fig. 10 B

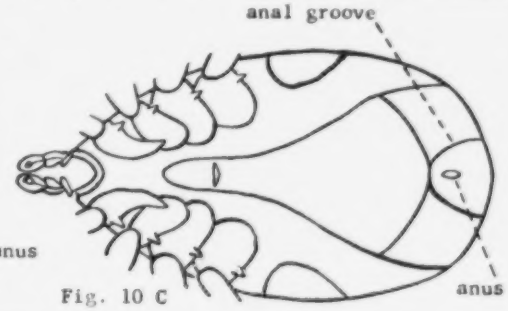


Fig. 10 C

FAMILY ARGASIDAE - SOFT TICKS

11. Margin of body with a definite sutural line separating dorsal and ventral surfaces; dorsal surface with conspicuous "discs" arranged somewhat in radiating lines (Fig. 11 A) Argas persicus.....FOWL TICK

Margin of body lacking definite sutural line, thick and rounded (Fig. 11 B).....12

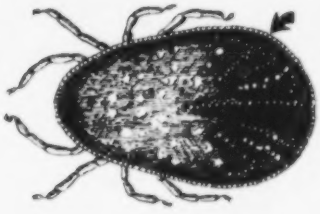


Fig. 11 A

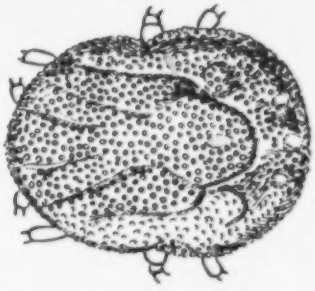


Fig 11 B

12. Hypostome with well-developed teeth (Fig. 12 A); integument not spinose..... Genus Ornithodoros.....13

Hypostome of adult vestigial or without effective teeth; integument of nymph (stage usually seen) spinose (Fig. 12 B). Usually on cattle and horses..... Otobius megnini.....SPINOSE EAR TICK

Fig. 12 A

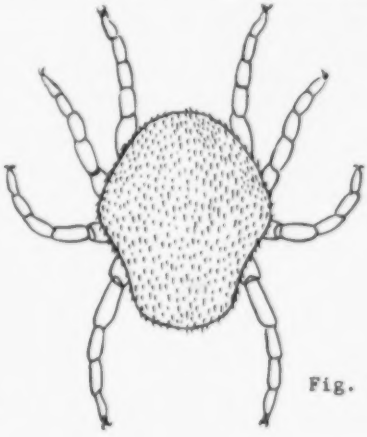


Fig. 12 B

13. Strong dorsal humps absent on all tarsi (Fig. 13 A).....14

Strong dorsal humps present on tarsi of first, second and third legs (Fig. 13 B).....15

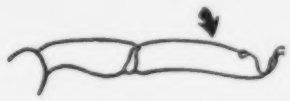


Fig. 13

Fig. 13 B

14. Cheeks absent (Fig. 14 A). Ornithodoros hermsi.....HERMS' RELAPSING FEVER TICK

Cheeks present (Fig. 14 B).....Ornithodoros talaje

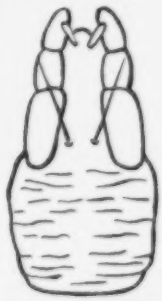


Fig. 14 A

Fig. 14 B

15. Eyes present on sides of body above second and third coxae (Fig. 15 A); tarsus of fourth leg with a prominent, pointed subterminal spur (Fig. 15 B)..... Ornithodoros coriaceus.....PAJAROELLO TICK

Eyes absent; tarsus of fourth leg without such subterminal spur (Fig. 15 C).....15

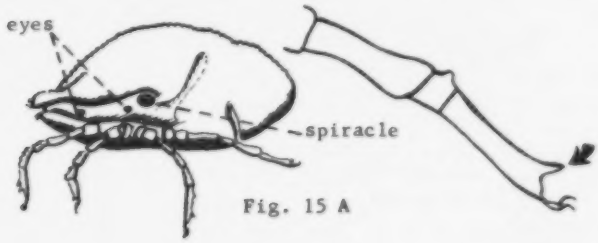


Fig. 15 A

Fig. 15 B

Fig. 15 C

16. Mammillae large, relatively few and not crowded; in mid-dorsal region about 10 per linear mm.; hypostome over 1/2 mm. long. Southeastern United States and Mexico north to Kansas and Florida. Ornithodoros turicata.....RELAPSING FEVER TICK

Mammillae small, crowded, and numerous; in mid-dorsal region about 18 per linear mm.; hypostome less than 1/2 mm. long. Pacific coast and Rocky Mountain states..... Ornithodoros parkeri.....PARKER'S RELAPSING FEVER TICK

CHECK LIST OF TICKS FOUND IN THE UNITED STATES

FAMILY IXODIDAE

Genus Amblyomma Koch -- Revision by Cooley and Kohls,1944b
Amblyomma americanum (Linnaeus)
Amblyomma cajennense (Fabricius)
Amblyomma dissimile Koch
Amblyomma inornatum (Banks)
Amblyomma imitator Kohls
Amblyomma maculatum Koch
Amblyomma tuberculatum Marx

Genus Anocentor Schulze (American reference as Otocentor Cooley, 1938)
Anocentor nitens (Neumann) (as Otocentor nitens, Cooley, 1938)

Genus Aponomma Neumann
Aponomma elaphensis Price, see Price, 1958

Genus Boophilus Curtice, Revisions by Cooley, 1946; Hoogstraal, 1956
Boophilus annulatus (Say)
Boophilus microplus (Canestrini)

Genus Dermacentor Koch, Revision by Cooley, 1938
Dermacentor albipictus (Packard)
Dermacentor andersoni Stiles
Dermacentor halli McIntosh
Dermacentor hunteri Bishopp
Dermacentor occidentalis Marx
Dermacentor parumapertus Neumann
Dermacentor variabilis (Say)

Genus Haemaphysalis Koch, Revisions by Cooley, 1946; Kohls, 1960
Haemaphysalis chordeilis (Packard)
Haemaphysalis leporispalustris (Packard)

Genus Ixodes Latreille, Revision by Cooley and Kohls, 1945
Ixodes affinis Neumann, see Kohls and Rogers, 1953
Ixodes angustus Neumann
Ixodes auritulus Neumann
Ixodes baergi Cooley and Kohls
Ixodes banksi Bishopp
Ixodes brunneus Koch
Ixodes californicus Banks
Ixodes conepati Cooley and Kohls
Ixodes cookei Packard
Ixodes dentatus Marx
Ixodes diversifossus Neumann
Ixodes hearlei Gregson
Ixodes holdenreidi Cooley, see Cooley, 1946b
Ixodes howelli Cooley and Kohls
Ixodes jellisoni Cooley and Kohls
Ixodes kingi Bishopp

Ixodes marmotae Cooley and Kohls
Ixodes marxi Banks
Ixodes minor Neumann, see Clifford, et al., 1961
Ixodes muris Bishopp and Smith
Ixodes neotomae Cooley
Ixodes ochotonae Gregson
Ixodes pacificus Cooley and Kohls
Ixodes peromysci Augustson
Ixodes rugosus Bishopp
Ixodes scapularis Say
Ixodes sculptus Neumann
Ixodes signatus Birula
Ixodes soricis Gregson
Ixodes spinipalpis Hadwen and Nuttall
Ixodes texanus Banks
Ixodes tovari Cooley, see Eads and Hightower, 1951
Ixodes uriae White
Ixodes woodi Bishopp

Genus Rhipicephalus Koch, Revision by Cooley, 1946a
Rhipicephalus sanguineus (Latreille)

FAMILY ARGASIDAE, See Revision by Cooley and Kohls, 1944a

Genus Argas Latreille, Revision by Cooley and Kohls, 1944a
Argas brevipes Banks, see Kohls, et al., 1961
Argas cooleyi Kohls and Hoogstraal, see Kohls and Hoogstraal, 1960
Argas persicus (Oken)

Genus Antricola Cooley and Kohls, Revision by Cooley and Kohls, 1944a
Antricola coprophilus (McIntosh)

Genus Ornithodoros Koch, Revision by Cooley and Kohls, 1944a
Ornithodoros aquilae Cooley, see Cooley, 1944
Ornithodoros capensis Neumann (Hawaii only)
Ornithodoros concanensis Cooley and Kohls
Ornithodoros cooleyi McIvor
Ornithodoros coriaceus Koch
Ornithodoros dyeri Cooley and Kohls
Ornithodoros eremicus Cooley and Kohls
Ornithodoros hermsi Wheeler, Herms, and Meyer
Ornithodoros kelleyi Cooley and Kohls
Ornithodoros parkeri Cooley
Ornithodoros stageri Cooley and Kohls
Ornithodoros talaje (Guerin-Meneville)
Ornithodoros turicata (Duges)
Ornithodoros yumatensis Cooley and Kohls

Genus Otobius Banks, Revision by Cooley and Kohls, 1944a
Otobius lagophilus Cooley and Kohls
Otobius megnini (Duges)

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TICKS AND TICK-BORNE DISEASES. (M-346). USPHS, CDC, 1960. Motion picture, color, sound, 672 feet, 16 mm., 19 minutes.

IDENTIFICATION OF U. S. GENERA OF ADULT TICKS. (5-130). USPHS, CDC, 1950. Filmstrip, black and white, 81 frames, 35 mm. and disc, 1 side, 16 inch, 33 1/3 rpm., 14 minutes.

THE GENERA OF NORTH AMERICAN TICKS. (F-139). USPHS, CDC, 1953. Filmstrip, color, 37 frames, 35 mm. and disc, 1 side, 16 inch, 33 1/3 rpm., 4 minutes.

THE LIFE HISTORY OF THE ROCKY MOUNTAIN WOOD TICK. USPHS, Rocky Mountain Laboratory, 1939. Motion picture, color, silent, 16 mm., 33 minutes. Available through Armed Forces Institute of Pathology, Walter Reed Army Medical Center, 6825 16th Street, N. W., Washington 25, D. C. One copy for limited use in CDC Film Library.

THE STORY OF ROCKY MOUNTAIN SPOTTED FEVER. USPHS, Rocky Mountain Laboratory, about 1940. Motion picture, color, silent, about 25 minutes. Copies may be available from the Rocky Mountain Laboratory, Hamilton, Montana. One copy for limited use in CDC Film Library.

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